Realities of Long-Term Post Investment Performance for Venture-Backed Enterprises

Gavin C Reid[†] and **Julia A Smith***

Abstract

This paper constructs a model of long-run performance for SMEs that have received venture capital backing. The model explains performance by financial structure. FAME data are used for estimating performance equations over the period 1989 to 2004 for UK businesses in their post-investment period. The econometrics uses robust techniques, including least absolute error (LAE) and Tukey trimean estimation. It is shown that the key determinants of performance (measured by ROSF) are profit margins and risk, with lesser, but significant, roles played by liquidity and gearing. The sample is used to identify consistently high performers, and chronic low performers. From the latter group, two detailed case studies illustrate how chronic low performance can emerge, in each case caused by failure to achieve technological milestones, and thereby failing, ultimately, to convince investors of potential company worth.

Key Words: venture capital, investment performance, LAE estimation, research milestones

JEL Classification: G24, G32, L25, M13, O32

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1. Introduction

This is a quantitative paper, supported by case study evidence, which focuses on the post-investment performance (cf. Murray and Marriott, 1998) of long-lived SMEs which have acquired venture capital (including private equity) funding over the long term. Performance is measured by rate of return on shareholder funds. Least absolute errors statistical methods, and other techniques of robust regression methods are used to develop methods of performance which focus on financial structure. Building on this, classes of consistently high, and persistently low, performance are identified. By longitudinal analysis, it is shown that, from the long run standpoint, some well-known UK companies, often high technology companies, in which investment has been heavy, have proven to be poor long-term investment propositions. Two case studies of Scottish high-technology companies illustrate this finding.

2. Methodology

The key proposition is: venture capital investment has a positive long run impact on the performance of investee firms (Arundale, 2002, Engel, 2004, Fisken and Rutherford, 2002, Wang and Ang, 2004). This hypothesis is to be challenged by the data gathered and analyzed. The method adopted in this paper is (a) to seek a robust model of performance over the long-term; (b) to identify consistently high, and persistently low, performers in a sample of long-lived SMEs which have enjoyed an infusion of venture capital early in their company history; and (c) to illustrate the

morphology of low performance with two case studies. Our work extends previous research undertaken on strategies and techniques for venture investing (cf. Freel, 1999, Kaplan and Stromberg, 1982, Mitchell et al, 1995, 1997, 1999, Sapienza et al, 2000, Schefczyk, 2001, Wright and Robbie, 1996).

The method adopted uses data from the FAME database, which permits a longitudinal tracking of firms. This database provides evidence on many key financial variables, and also a continued history of evolution by risk class. Our own dataset construction involved two main activities: first, tracking companies through changes in name and/or company form; and, second, classifying firms found to be dormant, in receivership or liquidated. Changes were carefully traced and noted through use of the UK Companies House and FAME databases; and a separate variable for dissolved organizations was introduced to the database. The data used for performance analysis included: turnover, profit (or loss) before taxation; net tangible assets; shareholders funds; return on shareholders funds; return on capital employed; liquidity; gearing; and employees. In addition, where available, credit assessment measures were also gathered. Using these data, performance equations were estimated, using robust statistical methods based on regression quantiles. Econometric estimation was undertaken using *Shazam* software. Finally, a data search was used to distinguish between high and low performers, over the lifetime of the sampled companies (cf. Bollingtoft et al, 2003).

Case studies used to illustrate the findings involve two famous companies: Pharmaceutical Proteins, which specialized in transgenic technologies, and was the first to clone an animal (Dolly the Sheep); and Shield Diagnostics, which specialized in in-vitro diagnostic products, and originally sought cheap diagnostic test procedures for AIDS, before shifting interest to other diagnostic areas, including the detection of

syphilis, diabetes and coronary heart disease. Though attracting large volumes of venture funding, and creating much novel intellectual property, these companies are shown to have been poor long run investment propositions (cf. Robinson & Min, 2002). At the same time, we note (Reid and Smith, 2003) that it is possible to find less well known companies (like KPOS, which produces 'point of sale' software for retail businesses), which are still information and human capital intensive, but are not development companies, can have very good long term performance (Bouresli et al, 2002, Jain and Kini, 1995, Zucker et al, 2002).

Previous research findings on the impact of venture capital investment on the performance of investee companies are equivocal. At one end of the spectrum, are studies by Zucker et al (2002), Jain and Kini (1995), Keeley and Roure (1990), and Ammons (2000) which argue that there is a positive, if complex, relation between venture capital intervention and investee performance. On the other hand, studies by Flynn and Forman (2001), Hamilton (2001) and Gersick (1994) find that the performance relationship between the venture capitalists and entrepreneurs is contingent and endogenous. It depends on the stage of investment; and venture capitalists and entrepreneurs can themselves affect performance in different ways (cf. Higashide and Birley (2002), Shepherd et al (2005), Sweeting and Wong (1997). Both effects can have a negative impact on performance.

Our study aims to resolve these opposing bodies of opinion. Our general findings suggest rejecting the key proposition in its strict form. The work serves as a corrective to the view that low-performing high technology firms are only a dot.com meltdown phenomenon. Our study finds that firms founded well before this period in the early 2000s often lacked superior performance (cf. Arundale, 2002, Fisken and Rutherford, 2002). This does not mean they will not make better returns in the future,

and does not imply irrelevance of such companies to the 'business ecology' of an advanced information intensive economy (e.g. in terms of positive spillover benefits). It does mean that venture capitalists with quite short time horizons will be unlikely to harvest the full benefits of such companies.

3. Data and Analysis

The data on which the analysis is based relate to 31 companies which had received venture capital investment, and whose Directors were interviewed either face-to-face or by telephone interview in 1994 (Reid, 1998). They covered a broad range of industries, from funeral directors to radio stations, computer recognition systems to biotechnology research, and hotel management to clothing manufacture. For this paper, new financial data on these companies were gathered from the FAME[1] database for each year from as early as 1989 (where relevant and available) to 2004, inclusive. Nominal financial data were deflated to real terms (1989 = 100) using the National Statistics' Retail Price Index. Descriptive statistics for key financial variables used in our analysis are contained in Table 1 below, and variable definitions are contained in the Appendix.

A total of 327 observations on the sampled companies are potentially available for any one variable. However, each variable has missing data, and these lacunae vary across variables. This reduces the potential sample size for econometric estimation somewhat. The *Profit Margin* variable (N = 195) has the most missing data, so the effective sample size is typically around N = 150 for the econometric estimates reported upon below - certainly adequate data for serious inferential work.

[1] Financial Analysis Made Easy

Table 1: Summary Statistics for Key Variables (see Appendix for definitions)

Variable	N	μ	σ	Min	Max
Profit Margin	195	3.39	19.05	-89.35	59.28
ROSF	229	18.26	137.76	-944.64	540.73
ROCE	256	17.42	107.88	-975.52	540.73
Liquidity	299	1.76	2.12	0.0700	19.91
Gearing	251	164.47	404.61	0.0200	3853.4
Employment	256	251.06	322.36	3.000	1703.0
Qui Score	306	54.745	23.97	1.000	96.00
Qui Rating	263	52109.0	35955.0	534.0	1×10^5

The first thing to observe from Table 1 is that some companies have a very poor financial showing over the sample period. To illustrate, the mean (μ) profit margin over the period is only 3.39%, and the minimum is almost – 90%. Both return on shareholders' funds (ROSF) and return on capital employed have impressively high (and similar) mean (μ) values at 18.26% and 17.42%. This befits returns in the high risk/ high returns area. Reflecting this risk, very large negative values of these returns variables are possible in any given year, so the high positive average values are that much more remarkable. Under some accounting conventions ROCE and ROSF will give identical values, this being true of the maximum value in each case of approximately 540%.

Indeed, for positive values, both ROSF and ROCE are quite close in the sample. Thus, a graphing of these values (not shown) shows them to be closely clustered on, and about, a 45° line in the first (positive) quadrant. In the third quadrant (ROSF < 0, ROCE < 0) the picture is rather different, with a tendency for ROSF to be much more sharply negative than ROCE. For this reason, the overall correlation of ROCE and ROSF is not very high for the sample as a whole (N = 228), though it is highly statistically significant (e.g. for a linear regression of ROSF on ROCE;

prob. value = 0.000). Given the similar behaviour of ROSF and ROCE, we have chosen to focus on just ROSF in undertaking performance estimates and reporting. The results are very similar when ROCE is used as a rate of return variable.

The basic model to be reported upon here (cf. Chang et al, 2003, Claessens et al, 2000) has the general form:

$$Performance = f(Financial\ Structure) \quad \textbf{(1)}$$

In this paper, the specification of (1) that will be used is:

$$ROSF = f(Profit\ Margin, Liquidity, Gearing, Security) \quad \textbf{(2)}$$

These variables are all defined in the Appendix. *ROSF*, *Profit Margin*, *Liquidity* and *Gearing* are defined in conventional ways (cf. Asthana & Lipka, 2002). What is described here as 'security' is actually the inverse-risk measure as calibrated by the *Qui Score*. This proprietary risk measure runs from 0 (high risk) to 100 (highly secure). It is, in effect, a measure of the likelihood of company failure (cf. Beaver, 2003, Headd, 2003, Bunn & Redwood, 2003).

The model of equation (2) is to be estimated by robust regression techniques, rather than regular least squares regression techniques, which are vulnerable to problems of outliers and specification error (e.g. non-normality of disturbances). The general estimation technique adopted uses regression quartiles (Koenker and Bassett, 1978). The minimand for this technique is:

(3)

which is the θ^{th} sample regression quantile for $0 < \theta < 1$, for which the solution is some $\hat{\beta}(\theta)$. When $\theta = 0.5$ this reduces to the least absolute errors (LAE) estimator, for which the β sought are those which minimise $\sum|y - X\beta|$. As usual, y is a set of observations on the dependent variable, X is a metric of observations on the independent variables, and the operator $|.|$ denotes absolute values. Computation is by linear programming, using the simplex method (Wagner, 1959).

Table 2 reports on LAE estimation, in which 153 of the available 327 observations were usable. For this sub-sample, the mean value for the return on shareholders' funds (*ROSF*) was approximately 24%. All coefficients are highly statistically significant.

Table 2: Dependent Variable: *Return on Shareholders' Funds* (ROSF)

Independent Variables	$\hat{\beta}$	**t-ratio**	**Elasticity**
Profit Margin	3.542	32.92***	1.011
Liquidity	4.924	4.602***	0.295
Gearing	-0.0364	-5.096***	-0.152
Qui Score	-0.489	-6.214***	-1.287
Constant	25.173	5.662***	1.046

***Significant at 1% level (148 d.f.)
Mean of ROSF = 24.074

Not surprisingly, the profit margin has a relatively large proportional effect on the *ROSF*. A 10% increase in the profit margin will raise the *ROSF* by approximately 10% as well. More marked, the security from risk measure (*Qui Score*) has a negative and highly elastic (in the sense of an elasticity greater than unity in absolute value) impact on *ROSF*. A 10% increase in security from risk leads (other things being equal) to an approximately 13% decrease in return on shareholders' funds. You do

get companies that are very secure (in the case of the *Qui Score*, which rates on a 100 point scale, from 0 highest risk to 100 highest security, a score of 81-100), but this security, as one would expect, dampens considerably the return (cf. Kahya et al, 2001, Lev, 2000).

Liquidity, here measured by [current assets-stock ÷ current liabilities], is, like the profit margin, positively correlated with *ROSF*, but a 10% increase in liquidity has (approximately) just a 3% positive impact on ROSF. *Gearing*, here measured as (long-tem liabilities + short-term loan + overdraft) ÷ (share capital + reserves), has a mild negative effect on ROSF, with a 10% increase in gearing leading to just a 1.5% decrease in ROSF. We can see from the summary statistics in Table 1 that venture backed firms can be quite highly geared, as the mean value is 164%. However, the reciprocal of the coefficient of variation (σ/μ) is quite low at $164.47 \div 404.61 \approx 0.406$, as gearing has a lot of variation in the sample, indeed, from zero to several thousand, across firms and years. It is by no means obvious that a Miller-Modigliani world is relevant here. Indeed, gearing policies do seem to vary widely across companies. One explanation for this is that optimal gearing trajectories can, in theory, take diverse forms, depending on the characteristics of the firm, and its stage in the life-cycle (Hilten, Kort and Loon, 1993), Reid (2003).

One feature of relevance to company characteristics is risk-class. In our case, our proxy for risk is obtained from the *Qui Score*, which has a metric which is the reciprocal of risk. Optimality of gearing trajectory is defined for a specific risk class, and for this sample a wide variety of risk classes is represented, which again will lead to wide variation in gearing policy.

Table 3: Tukey Trimean Estimation

Independent Variables	$\hat{\beta}$	t-ratio	Elasticity
Profit Margin	3.967	60.88***	1.132
Liquidity	5.129	7.913***	0.307
Gearing	-0.0457	-10.55***	-0.191
Qui Score	-0.585	-12.27***	-1.540
Constant	29.424	10.93***	1.222

***Significant at 1% level (148 d.f.)
Dependent Variable: ROSF
Mean of ROSF = 24.074

An alternative to the LAE estimator is represented in Table 3. It involves use of the Tukey trimean estimator [Rosenberger and Gasko (1983)], the trimean being a measure of central tendency, based on the arithmetic average of the values of the first quartile, the third quartile, and the median counted twice. Tukey's estimator is based on a linear function of regression quantiles of the form $\hat{\beta}(\pi) = \sum_i w_i \hat{\beta}(\theta_i)$ where the w_i are a symmetric weighting scheme. In this case, the vectors θ and w were assigned values (0.25, 0.5, 0.75) and (0.25, 0.5, 0.25) respectively. Convergence was obtained, using the simplex algorithm, in eighteen sample iterations.

It can be seen that the results in Table 3 confirm the earlier results of Table 2, and comments about them in Table 2 largely carry over to Table 3. The more sophisticated Tukey trimean estimation slightly changes the coefficients of β and the value of the elasticities at the means, and the statistical significance has risen for all regression coefficients. However, all regression coefficients remain of the same sign, and the order of magnitude (and, indeed, the relative magnitude) of regression coefficients, have been little changed. If anything, elasticties have increased somewhat, and predicted consequences for *ROSF* of percentage changes of

independent variables have risen, notably for the profit margin and for the *Qui Score*. The results of Table 2 and Table 3 together increase our confidence in the robustness of the results reported.

For the sample of firms used (*viz*. the base period sample of Reid's (1998) study, updated to the present day), the proportion of high and low performances is indicated in Table 4. Thus, not only are some firms in the low performance category, they are ubiquitous in their appearance in this category. For example, Firms T01 (left hand column) is a biotechnology firm with persistently poor performance over much of the sample period (over two decades). Contrariwise, Firm T02 (right hand column) is a company for a radio station which has enjoyed a persistently good performance over much of the sample period.

Using the mean of the dependent variable *ROSF* in the models of Tables 2 and 3, we also, of course, can split the sample of firms into high and low performers, as in Table 4. This is to use a rather more stringent condition than using the mean of *ROSF* from the summary statistics of Table 1, as in Table 4. If the mean from Table 1 (*viz*. *ROSF* = 17.99% – see Table 4) is used for the sample split, then four firms (L, P, T02, T13) were always only in the high performing category, and six firms (D, J, J2, T01, T08, T14) were always only in the low performing category. This same sample split held if *ROCE* were used (with *ROCE* = 17.42% as the hurdle performance rate). The top performing group is not modified if one moves to the more stringent splitting criterion of Table 2 and 3, namely *ROCE* = 24.07%. Two of the lowest performing firms (PPL and Shield) examined (on a case study level) later in the paper would be the lowest performers under both sample splits. Further, the splits would retain these firms in the lowest performance category under each of the *ROSF* and *ROCE* measures (and both).

Table 4: Proportion of High or Low Performance

LOW (ROSF ≤ 17.99%)		HIGH (ROSF > 17.99%)	
FIRM ID	%	FIRM ID	%
D	9	E	7.5
E	2.8	F	0.8
F	4.6	G	6.7
G	3.7	H	3.3
H	9.2	K	2.5
J	6.4	L	2.5
J2	7.3	M	0.8
K	3.7	N	3.3
M	4.6	P	3.3
N	3.7	P2	4.2
P2	6.4	Q	9.2
Q	2.8	R	5.0
R	2.8	T02	10.8
T01	12.8	T03	9.2
T03	1.8	T05	3.3
T05	3.7	T10	10.0
T08	2.8	T11	1.7
T10	0.9	T12	2.5
T11	11.0	T13	11.7
T12	4.6	T15	1.7
T14	1.8		
T15	1.8		
TOTAL	**100**	**TOTAL**	**100**

Essentially, the evidence is that only a small number of firms have shown consistently good performance over the sample period. In the middle is a mixed group which has, as one might expect, experienced the highs and lows of good and bad fortunes. Finally, there is a third group of firms, proportionately quite numerous (27%) which, throughout the period, have had only low performance. From this group, we have selected two for further case study analysis, *Pharmaceutical Proteins* and *Shield Diagnostics*, both of which have enjoyed great celebrity, but both of which have had disappointingly (and persistently) low performance.

4. Case Studies

Two illustrative case studies are given below, as an indication of the types of companies in which venture capitalists in the UK were investing in the early 1990s. Both were extremely promising high-technology companies. The first, *PPL Therapeutics (Scotland) Limited* (PPL), was involved in early cloning and transgenic technology development. The second, *Shield Diagnostics Limited* (Shield), hoped to develop tests for HIV and AIDS. As we shall see, each suffered through the failure of technologies to achieve milestones in development and, ultimately, through not achieving the high hurdle rates of return imposed by venture capital investors.

It is possible to link directly the model of equations 1 to 3 (and results of Tables 2 to 4) above, to the specific performance attributes of the firms chosen for the case study analysis, namely PPL (Firm J) and Shield (Firm J2). Table 5 provides information on both the dependent variables (*ROSF*) and the independent variables (*Profit Margin*, *Liquidity*, *Gearing*, *Qui Score*) of the model, as applied to these two cases.

We note, first, that performance was both choppy, and frequently poor, as measured by *ROSF*, for both PPL and Shield. At Worst, PPL had a *ROSF* of - 944.64% in 1998; and Shield a *ROSF* of - 459.45% in 2000. Only rarely was *ROSF* even positive for either firm, and the best annual *ROSF* of either firm (15.86% for Shield in 1996) was itself below the sample average of 17.99%.

Second, we note that the explanatory variables of our model, on the capital structure side, all remorselessly suggest corporate financial stress for both firms. The *Profit Margin* is rarely reported for PPL, and is positive just once, at 1.59% and then negative at - 30.99%. Shield usually did report the profit margin, but it was rarely

positive, and Shield's average for the sample period was - 24.63%. A similar general picture is found with *Liquidity*, which declined on average for PPL over the sample

Table 5: Key Financial Variables for PPL and Shield

ID	*Year*	*Return on Shareholders' Funds*	*Profit Margin*	*Liquidity*	*Gearing*	*Qui Score*
I. PPL Therapeutics						
J	1992	.31	1.59	8.10	5.64	78.00
J	1993	-32.60	N	5.75	8.15	46.00
J	1994	-40.11	N	9.38	61.20	46.00
J	1995	-31.55	-30.39	7.57	286.67	46.00
J	1996	N	N	4.13	3853.43	19.00
J	1997	N	N	.58	2606.46	9.00
J	1998	-944.64	N	.37	849.68	13.00
J	1999	N	N	.36	2853.58	8.00
J	2000	N	N	1.34	1242.84	22.00
J	2001	-243.13	N	4.33	233.33	46.00
J	2002	-632.89	N	1.24	237.33	32.00
J	2003	N	N	2.10	1143.59	36.00
II. Shield Diagnostics						
J2	1992	-145.18	N	.90	57.11	9.00
J2	1993	-195.06	-38.84	.65	229.09	N
J2	1994	N	-14.80	1.74	N	2.00
J2	1995	6.73	2.30	2.34	135.37	68.00
J2	1996	15.86	4.74	2.59	113.42	71.00
J2	1997	-342.73	-24.30	1.62	403.54	29.00
J2	1998	N	6.94	1.92	N	26.00
J2	1999	N	-45.23	4.00	N	N
J2	2000	-459.45	-89.35	4.57	704.79	24.00
J2	2001	N	-44.15	2.89	N	1.00
J2	2002	-32.72	-24.15	7.19	94.72	46.00
J2	2003	1.07	.72	3.00	111.80	81.00

N = Null return

period, sometimes assuming dangerously low values (e.g. 0.36 in 1999), and always being relatively low for *Shield* (rarely more than one standard deviation above the sample mean). For *Gearing*, that is leverage, the average figure for the sample as a

whole is high at 164.47%, as one might expect of the high risk investment opportunities in which venture capital is involved. However, even in a risky world, it was exceptional for *Gearing* to go as high as the peak values of 3853 % (in 1996)and 705 % (in 2000), for PPL and Shield, respectively, suggesting huge levels of risk, and very high probabilities of corporate failure.

Indeed, this latter observation is confirmed by the *Qui Score* variable frequently dipping down to levels associated with high risk (e.g. 9 in 1997, 8 in 1999, for PPL; and 9 in 1992, 2 in 1994, and 1 in 2001, for Shield). In eight out of the 11 years for which we have data on PPL, the company fell into the 'high-risk' or 'unstable' categories, as defined by *Qui*. For Shield, the data are somewhat more turbulent. Six times out of 14 the company was considered to be 'high risk' or 'unstable', in four of our observed years it was considered to be 'normal'; and in an additional four years it was either 'stable' or 'secure'. The case studies aim to develop a richer empirical characterisation of both companies, including qualitative factors which might have contributed to the poor performance levels achieved.

Case Study I: *PPL Therapeutics (Scotland) Limited* (PPL)

PPL was started by a group of Edinburgh University research scientists in 1987, as Caledonian Transgenics Limited, in order to commercialise the activities of its research base. It soon became known as a leader in the science of transgenic production of human proteins. The company was based at what is now called the Roslin Institute, on the outskirts of Edinburgh, the capital of Scotland. This site provided the ideal rural location for a farm in which scientists could to conduct their experiments. They examined flocks of home-grown sheep and herds of cattle, with

the ultimate aim being 'to save human lives by altering animals so that they produce therapeutic proteins' (The Guardian, 2002, p.7).

Early-stage financing was provided in the form of venture capital from the Prudential financial services group. Rather than spend money on developing expensive high-tech bio-engineering facilities, PPL aimed to develop a product which could, quite simply, be provided from the farmed animals themselves. With a base established in Scotland, and the birth of its first transgenic sheep, Tracy, in 1991, PPL merged with an American company, TransPharm Inc, in 1993, thus creating the first multinational corporation developing transgenic technologies (PPL, 2004, web-site). This facilitated the company's achieving its first US patent for transgenic technology in 1994. At around the same time, what had become Pharmaceutical Proteins Ltd changed its name to PPL Therapeutics (Scotland) Limited. This is the name that exists today.

The year 1996 marked a breakthrough for PPL, when it achieved key commercial and technological milestone targets, including listing on the London Stock Exchange, the completion of a £7.2m production facility, and the opening of an additional sheep breeding and experimentation facility in New Zealand. PPL Therapeutics Plc became the holding company for PPL Therapeutics (Scotland) Limited (and, subsequently, for PPL (Holdings) Limited and PPL Genetics Limited) as the group divided its activities amongst several companies. In 1997, PPL's 'Dolly the Sheep' was born, the first cloned animal, making the company world-famous and pushing its share price up to 552p (Freeborn, 1998, p.59). PPL went on to produce cloned transgenic sheep in 1997 and cloned transgenic pigs in 2000-2001.

Following the furore caused by Dolly's arrival, both in terms of pushing forward the technological envelope, and in promoting serious reflection on new ethical issues,

PPL continued to develop its transgenic products. Although Dolly had been cloned successfully, she was not, in a strict sense, transgenic, nor did she have great milk-producing abilities. Seeking a more favourable farm setting, PPL started work on its East Friesian flock in New Zealand. This flock was better able to produce milk in the quantities required to make the product financially viable. A combination of Dolly's genes and East Friesian embryos was developed. As Dr. Ron James, then Managing Director of the company, explained at the time, 'Dolly was not genetically modified to our requirements, she was merely cloned. These new sheep have been altered by us … Without this breakthrough it would have taken years to breed enough sheep capable of producing large enough quantities of milk to extract commercially viable levels of the chemicals we need to produce drugs' (Doran, 1997, p.1).

Further developments followed. For example, PPL's 'peptide technology', made from the milk of genetically modified animals, was a product aimed at preventing excess growth of tissue after operations. PPL's scientific methodology meant that it could produce the drug more cost-effectively than through, for example, chemical processes. Extending its methodology led to further innovative developments, like the company's GSP-1 peptide (an alternative to insulin) and calcitonin peptide (to prevent brittle bones) (Wittett, 2000, p.22). In 2001, the production of cloned 'knockout' pigs again hit the headlines for PPL. These animals were born without the genes that cause humans to reject transplants, and were thought to have the potential for both full organ transplants and therapies for conditions like diabetes (Thomasson, 2001, p.14).

On the face of it, PPL should have been a successful company. It had strong financial backing and appeared to have continued scientific success. However, as Figure 1 shows, after peaking in 1995, turnover continued to fall. Employment grew

steadily until 1999, when cuts had to be made. However, the most telling line on the graph is profit, or increasing losses, which eventually spiralled out of control.

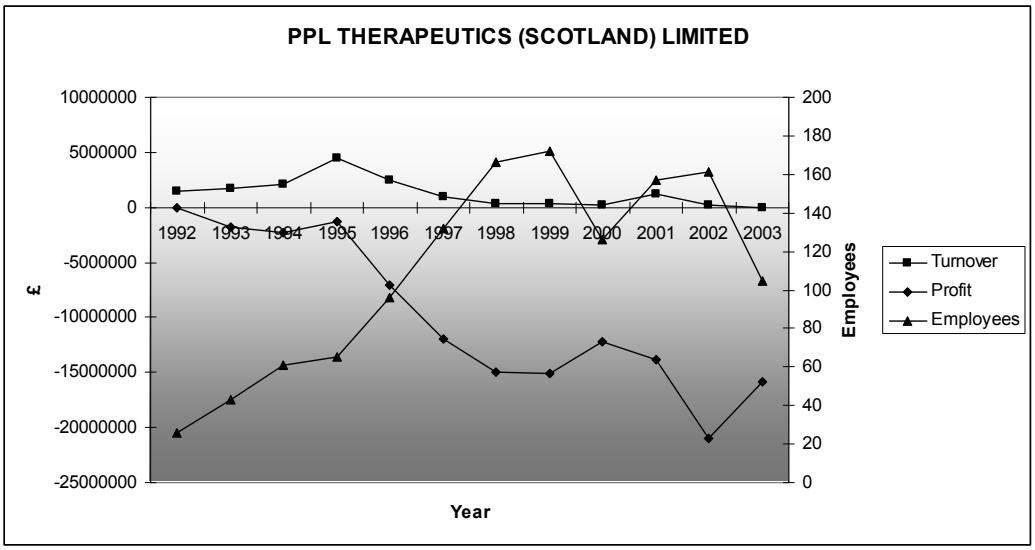

Figure 1: PPL turnover, profit and employment 1992-2003

There are a number of factors that could be considered to have contributed to the demise of PPL. First, there were obvious ethical considerations that might limit what the company did. For example, as reported in Doran (1997, p.1), 'Dr Donald Bruce of the Church of Scotland religion and technology project was said to be "very disturbed" … that human cloning experiments (were) to begin on the other side of the Atlantic'. The birth of Dolly provoked the then US President Bill Clinton to instruct a bioethics commission to report on the implications to society of her existence (Magee, 2002, p.6). Further, the anti-abortion activists made PPL's stem cell research difficult to promote and develop market support in the US (Nisse, 2002, p.3). And finally, perhaps even a touch of jealousy was shown on the part of the Americans who, according to Ron James, 'didn't see it coming, and as far as American are concerned they do the best science … (they) have never been able to come to terms with the fact that a small village on the outskirts of Edinburgh could achieve that kind of science –

on purpose' (Magee, 2002, p.6). Perhaps it is such negative publicity that led to larger than expected numbers of patients dropping out of recent trials of PPL's new drug for the treatment of emphysema (*Birmingham Post*, 2002, p.19).

Additional problems have also arisen in relation to funding further product developments. The company failed to raise the level of funding it needed through a rights issue, and found it increasingly difficult to attract new investors. The key fund-raising activity was not helped by the timing coinciding with the terrorist attacks of 11 September 2001 in the US. But, as one analyst explained, a possible reason for the lack of investor interest was that the diversification strategy of PPL had been confusing: 'I find it a very odd picture now. They started off doing walking factories for new drugs. Now they're into stem cell research and even generic biopharmaceuticals' (Clark, 2001, p.21).

Contributing factors might be the loss of a key member of the team, Dr Ron James, who retired as Chief Executive in 2001. PPL also found the balance between scientific endeavour and commercial viability difficult to manage. For example, following stock market listing, they had to reveal price-sensitive information, often before the technological milestones had been assessed and published in peer-reviewed scientific journals (*Daily Telegraph*, 2002, p.29). Their heavy reliance on German partners Bayer has also affected their performance. In 2003, Bayer suspended their plans to develop PPL's drugs from sheep milk, leading to the slaughter of hundreds of animals (Pfeifer, 2003, p.387). Together, these problems have forced the company to be wound up, or sold, with shareholders now only able to hope for 6p a share, at best.

Case Study II: *Shield Diagnostics Limited* (Shield)

In 1982 a group of life sciences research workers at Dundee University in Scotland launched a company intended to commercialise their work. It was incorporated as Shield Immunologicals Limited. However, it took another five years, until 1987, before the business really began to take off, with investment being drawn in from several venture capital companies. A total of £4.5m was invested, with Apax venture capital investors taking the role of lead investor. The newly funded company became Shield Diagnostics Limited. Shield concentrated on the development and manufacture of products, rather than on early or basic research. Marketing was undertaken by the multinational drug companies that bought Shield's products, who then sold them under their own brand names (*Investors Chronicle*, 1993).

In 1992 Shield purchased two infectious disease products, which were classified in the company's accounts as intangible assets. These were to be used to test, first of all, for chlamydia. But second, and most important, the company wished to develop tests for the cytomegla virus (cmv). This affects people with weakened immune systems, such as organ transplant patients; but most particularly, it poses a serious threat to those suffering from AIDS (Dorsey, 1997a). The Finance Director, when interviewed, was excited about the technological and commercial possibilities these two acquisitions would offer.

By the time of the interview, in 1994, the company was actively selling 14 auto-immune products, which were being used to give advance warning of conditions such as rheumatoid arthritis. It was also working on the development of a product aimed at diagnosing blood clotting. This was intended to be a major breakthrough in the treatment of heart disease, and was, at the time, going through clinical trials.

Although the company was loss-making in these early stages, there was optimism that it would break even during the year following its stock market listing in 1993 (*Chemical Week*, 1993). Nevertheless, the *Investors Chronicle* (1993, p.62) was cautious about potential 'speculative' investments in the company, stating that 'Shield is likely to come to the market in mid-September, valued at about £20m. Valuing such companies for stock market purposes is difficult, as yield and earnings multiple considerations do not apply. Shield has a nice £9.7m bank of tax losses, and little debt – this is strictly venture capital country – and the placing will raise £5.5m gross for Shield and £500,000 for directors'.

In reality, the company continued to make losses until 1995, when it began to make small profits (see Figure 2). It was during 1996 that Shield's Chairman, Hamish Hale, was reported in the press as saying that the company was negotiating a takeover, which was likely to require further investment. To encourage such investment, he said that the heart disease programme, which aimed to develop inexpensive diagnostic tests for predicting heart attacks, was 'going very well and very rapidly' (Durman, 1996, p.4).

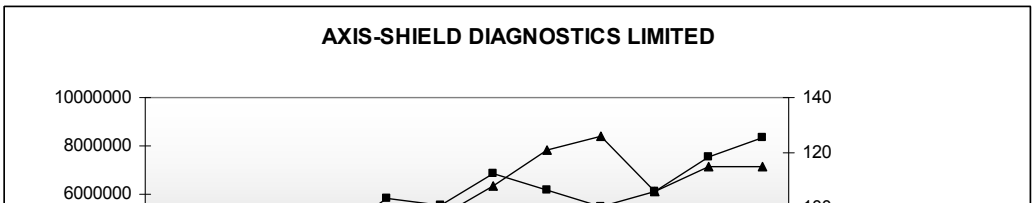

Figure 2: Shield turnover, profit and employment 1992-2003

In 1997, Shield was forced to issue a profits warning, stating that the losses it expected for the year to 31 March would be 'outside of the current range of market expectations' (Dorsey, 1997b, p.29). The reason for these greater than expected losses was put down to the reduced sales of the company's syphilis test and the writing-off of £387,000 worth of intangible assets. The latter was the book value of the products purchased in 1992 to test for the virus leading to AIDS. Along with declining profits, the company also made 12 staff redundant, in order to reduce overheads. This news hit the company's share price badly, and its closing price on 23 January 1997 was well down at 130p.

By July 1997, Shield had acquired for £2.4m a Canadian owned company (TTP Corporation), which enabled it to expand its portfolio of diagnostic products. TTP manufactured test products through a sub-contractor in England, and Shield's acquisition gave it the right to these tests and to TTP's working capital of £50,000 (Dorsey, 1997a). At this stage, Shield was also planning the future commercialisation of its test for cardiovascular risk (Activated Factor XII (AFT), which they hoped might prove to be a better predictor of heart disease than cholesterol-based measures. Such optimism moved the company's share price up to 452.5p.

When profits to March 1997 were finally released, they were in fact only slightly worse than had been anticipated, at £1.33m, compared to an expected £1m deficit (Dorsey, 1997b), but the company's share price, having been fairly buoyant, fell to 510p. A contributing factor to the falling share price was the lack of progress on Shield's development of its diagnostic test AFT. It was thought that it might take four to six months for the US Food and Drug Administration (FDA) to grant commercial approval of the product. However, management continued discussions with potential

partners, such as Johnson & Johnson and Abbott Laboratories, and remained optimistic about future developments.

By October 1997, Shield suffered another blow, at the executive level, with the unexpected departure of its Managing Director, Gordon Hall. Rumours abounded that he had come under increasing pressure because of a failure to sign a deal to commercialise AFT. The company's share price fell 97.5p to 620p on the news of his departure. While some blamed the drop on the fact that he had resigned, one sector analyst suggested that there was more to it, commenting that 'AFT is by far the most important product at Shield … it is crucial they get approval for this product, and crucial they get a good marketing partner on board. This rumour is suggesting that Gordon Hall was not making as much progress with that agreement as perhaps the company would have hoped and they really want to move him now because it is the rest of the Board that will be left with the decision' (Newton, 1997, 25).

Good news finally came for Shield in November 1997, with the rumour that Abbott Laboratories, based in Chicago, were close to finalising a deal to commercialise their AFT test. Shares rose to 697.5p at this good news (Newman, 1997). A year later, the newly-named Afecta test was set to launch on the market, having received approval from the FDAA in September 1998. The share price stood at 610p. A further product, testing for homocysteine, also aimed at testing for cardiovascular disease, was undergoing development. Each of these two tests were thought to be so-called commercial 'blockbusters', with the potential for global sales of over $1bn (Stokes, 1998, p.1).

After a long, slow start to life, by 2003, the company was looking forward to breaking into profit. Having merged with Axis Biochemicals in May 1999, and now called Axis-Shield, turnover was beginning to grow steadily (see Fig.2). Research

published in the *New England Journal of Medicine* gave encouraging support to the company's work on testing for homocysteine, which was linked to dementia and Alzheimer's disease. The Finance Director explained that 'previously our homocysteine product has been used in cases of cardio disorder. Now it could be used for a much wider market' Murray-Watson (2002, p.3). The company was now valued over £152m.

In June 2003, news broke that Axis-Shield had signed a major deal with Abbott Laboratories to develop 12 new tests for cardiovascular and other major diseases. According to the company's Chief Executive, the deal was expected to 'provide a significant future revenue stream for Axis-Shield' (Mackie, 2003, p.8). During 2004, Axis-Shield notified shareholders of the legal action it was pursuing against two US based companies, for infringement of their patents concerning the detection of heart conditions. While such action was obviously expensive, and potentially threatening to the very existence of the company, a satisfactory deal was arranged whereby Axis-Shield gained control of the technology, but would receive royalties on sales made by its rival. As Axis-Shield's Finance Director explained, 'no money is going to be changing hands as a result of this deal. We've now licensed this company, Catch, and will receive royalty payments from them, but we've also acquired worldwide exclusive rights for this technology. While it was infringing on our patent, it is good technology and is a good addition to the portfolio' (Dey, 2004, p.27).

After a turbulent few years, therefore, life for Axis-Shield begins to look better. Pre-tax losses to end June 2004 were down to £886,000 from £4.3 million the year before. Having dropped the controversial and unsuccessful AIDS diagnostics, the company now focuses it activities on tests for cardiovascular and neurological diseases, rheumatoid arthritis and diabetes. With renewed optimism, the chairman

stated that ‘our current products should produce strong growth and this will be supported by a substantial number of new products over the coming years’ (*Aberdeen Press and Journal*, 2004, p.20).

5. Conclusions

We have demonstrated how, in a technical sense, it is possible to create a robust model of long-run performance for SMEs which have received venture capital backing early in their life cycles. A key model which we expounded explained return on shareholders’ funds in terms of profit margin, liquidity, gearing and risk. This model was shown to be robust. However, such models may not capture the essentially flawed features of low performing venture backed firms. Two case studies are used to illustrate how failures to hit research milestones were crucial causes of long-term low performance for two venture-backed high-technology companies. Thus, it may not be possible to ‘financially engineer’ a development company out of poor economic performance, if its scientific capability is not as dynamic as expected. This may not be entirely the venture capitalist’s fault, but it provides stark counter-examples to the general claim that the consequences of continued and large venture capital support are always efficacious.

Appendix: Variable Definitions

employ	total employment
gear	gearing (expressed as %) (long term liabilities + short term loans & overdraft)/ (share capital + reserves)
liquid	liquidity ratio (current assets-stock)/ current liabilities
profmarg	profit margin (%)
quisc	Qui Score (see below)
quirat	Qui Rating - another measure of the Qui Score
roce	return on capital employed (expressed as a %) Profit before tax/ net assets (fixed + current assets – current liabilities)
rosf	return on shareholder funds (expressed as a %) Profit before tax/ shareholders funds

The QuiScore

The *QuiScore* is a measure of the likelihood of company failure in the twelve months following the date of calculation. It is given as a number in the range 0 to 100. For ease of interpretation, that range may be considered as comprising five distinct bands.

81-100 The Secure Band
Companies in this sector tend to be large and successful public companies. Failure is very unusual and normally occurs only as a result of exceptional changes within the company or its market.

61-80 The Stable Band
Here again, company failure is a rare occurrence and will only come about if there are major company or marketplace changes.

41-60 The Normal Band
This sector contains many companies that do not fail, but some that do.

21-40 The Unstable Band
Here, as the name suggests, there is a significant risk of company failure: in fact, companies in this band are, on average, four times more likely to fail than those in the Normal Band.

0-20 The High Risk Band
Companies in the High Risk sector may have difficulties in continuing trading unless significant remedial action is undertaken, there is support from a parent company, or special circumstances apply. A low score does not mean that failure is inevitable.

Source: Qui Credit Assessment Limited (1999).

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